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May 28, 1960

# ENVIRONMENTAL LEVELS OF RADIOACTIVITY FOR THE OAK RIDGE AREA

Report for 1959

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## Introduction

Radioactive waste materials arising from the operation of atomic energy installations at Oak Ridge are collected, treated, and disposed of according to their physical states.

Solid wastes are buried in a Conasauga shale formation. This shale has a marked ability to fix radioactive materials by an ion exchange mechanism.

Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to earthen pits located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams.

Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

## Air Monitoring

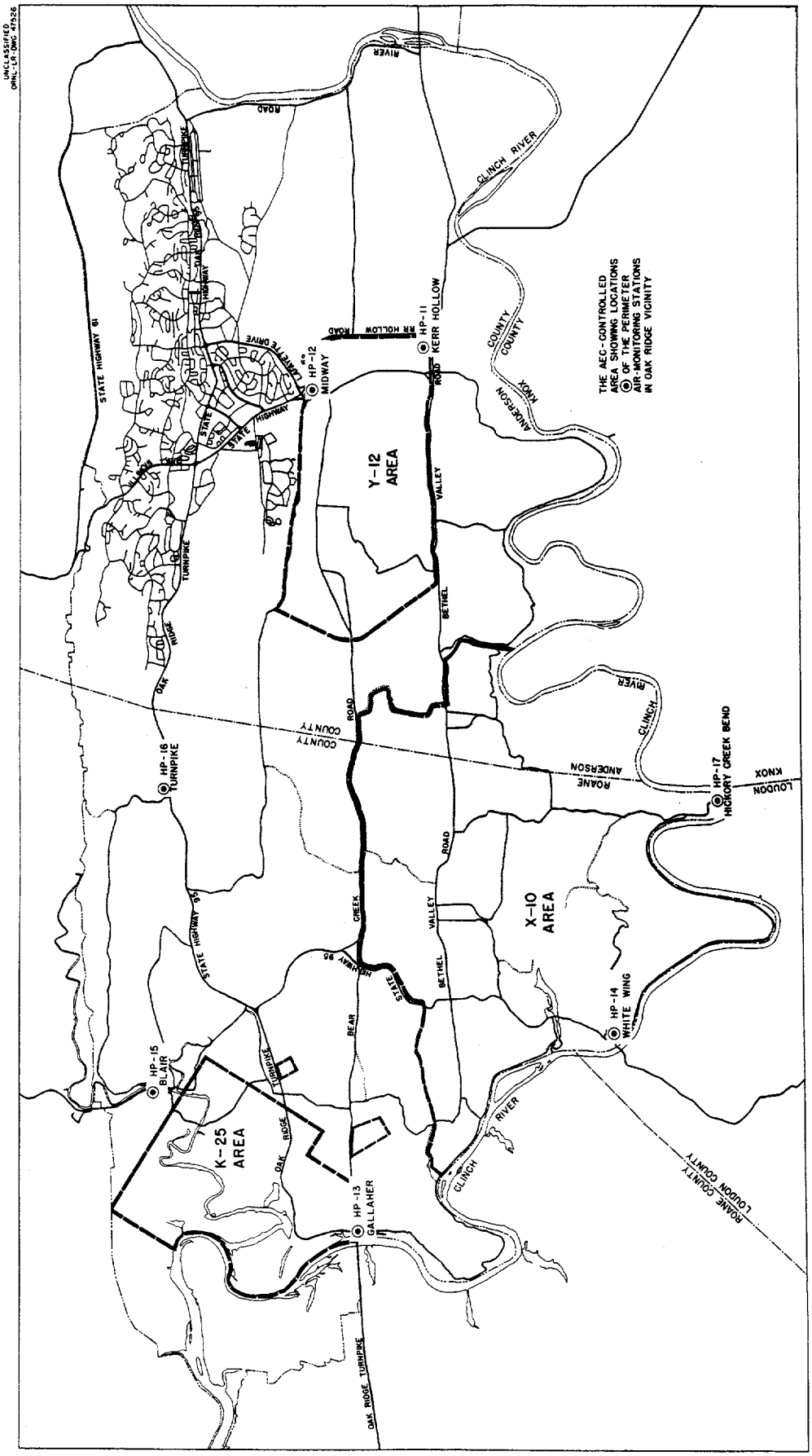
Atmospheric contamination and fall-out occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas (Fig. 1) and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 120 miles (Fig. 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Three types of samples are collected at the stations. One type is taken by passing air continuously through filter paper. The filter paper will collect only those particulates considered to be respirable. A second type utilizes a gummed paper technique for collecting fall-out The fall-out trays collect the heavier particles as well as the respirable particles. A third type is rain water which provides data for determining the soluble and insoluble fractions of the radioactive contamination.

Data obtained from the various sampling methods are accumulated and tabulated. In the case of the filter samples, data are tabulated in average $\mu c/cc$ of air sampled and numbers of particles per 1000 $ft^3$ of air sampled. In the case of gummed paper fall-out collection, data are tabulated in $\mu c/ft^2$ and numbers of particles per $ft^2$. In the case of rain water, data are tabulated in average $\mu c/cc$ of rainfall collected. The data are compared to established maximum permissible concentrations and with previous averages.

## Water Monitoring

Large volume, low level liquid wastes originating at Oak Ridge National Laboratory are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the Oak Ridge Gaseous Diffusion Plant and the Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with the maximum permissible levels for population in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection (NCRP). The concentration of radioactivity leaving White Oak Creek is measured and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.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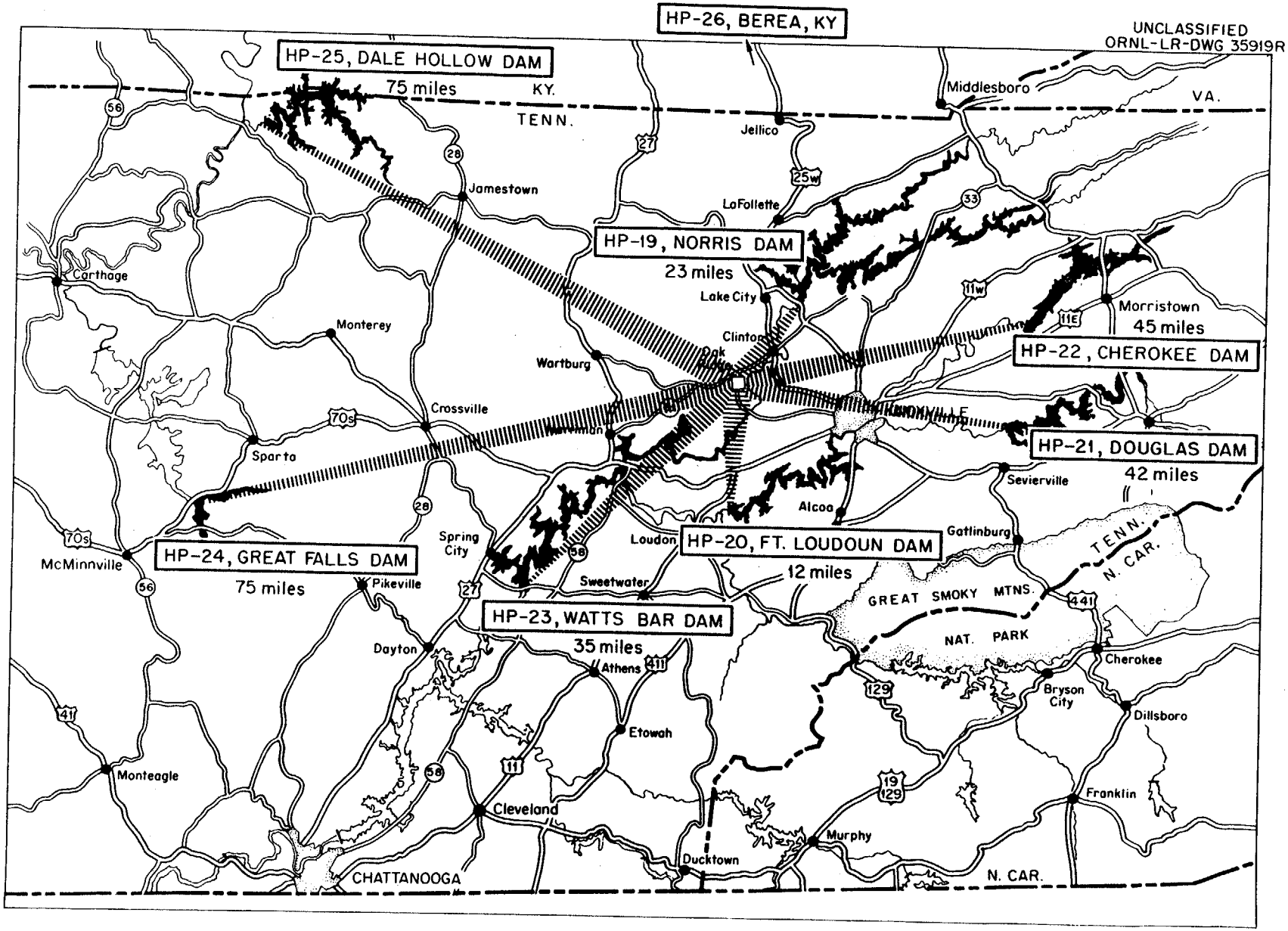
THE AEC-CONTROLLED AREA SHOWING LOCATIONS ◉ OF THE PERIMETER AIR-MONITORING STATIONS IN OAK RIDGE VICINITY
HP-11 KERR HOLLOW
HP-12 MIDWAY
HP-13 GALLAHER
HP-14 WHITE WING
HP-15 BLAIR
HP-16 TURNPIKE
HP-17 HICKORY CREEK BEND
Y-12 AREA
X-10 AREA
K-25 AREA
CLINCH RIVER
BETHEL VALLEY ROAD
OAK RIDGE TURNPIKE
STATE HIGHWAY 61
STATE HIGHWAY 95
BEAR CREEK
ROANE COUNTY
ANDERSON COUNTY
KNOX COUNTY
LOUDON COUNTY

Figure 1




STATION SITES FOR REMOTE AIR MONITORING SYSTEM

Figure 2

Radioactive liquid wastes are sampled at a number of locations as shown in Figs. 3 and 4. Samples are taken in Poplar Creek and White Oak Creek prior to entry of the wastes into the public waterway and at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the United States Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

The fraction of the total beta activity comprised by each isotope is determined from analysis of long-lived radionuclides contained in the effluent and a weighted average maximum permissible concentration for water, $(MPC)_w$, for the mixture of radionuclides is calculated on the basis of the isotopic distribution using the MPC values of each isotope as recommended by the NCRP. The average concentrations of radioactivity in the Clinch River are compared to the calculated $(MPC)_w$ value.

Annual surveys of the Clinch and Tennessee Rivers are conducted to determine the extent of dispersion of radioactive material in river sediment. This survey is required in order to determine whether or not there is a significant build-up of radioactive constituents in the river system. Gamma radiation measurements are made on the bottom sediments. Sediment samples are radiochemically analyzed for long-lived radioactive isotopes.

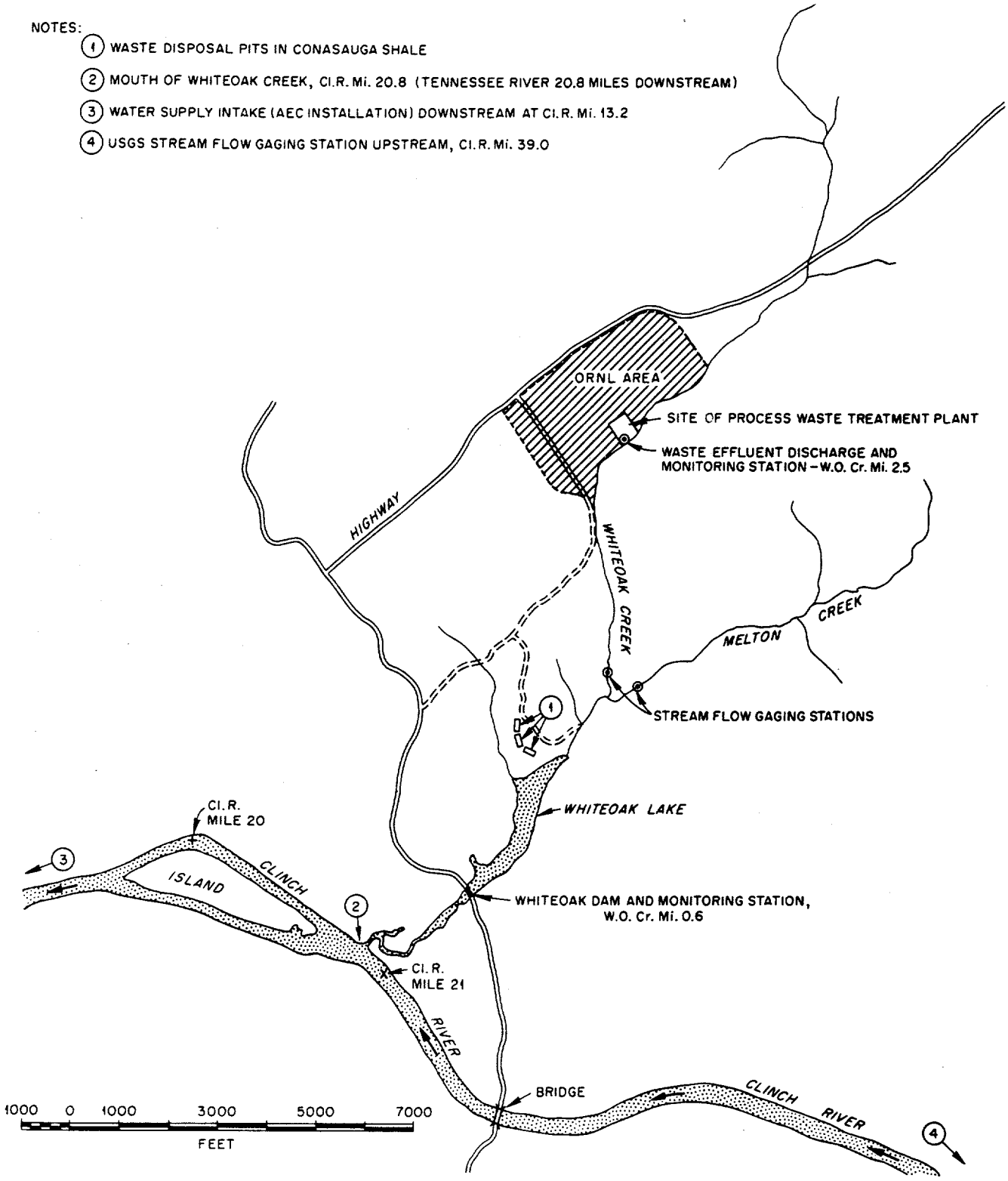
## Gamma Measurements

External gamma radiation levels are measured monthly at five locations in the Oak Ridge area. Measurements are taken with a Geiger-Muller tube at a distance of three feet above ground and the results are tabulated in terms of mr/hr.

## Discussion of Data

Data accrued from the monitoring system in 1959 are presented in Tables I through X.

The air contamination levels shown by the continuous air monitoring systems for the immediate and remote environs of the Oak Ridge area were 1.6% and 1.4% respectively of the maximum permissible concentration for populations in the neighborhood of a controlled area. Air contamination levels during the first half of 1959 were a factor of 4 to 6 times greater than the average for the entire year. By the end of 1959 air contamination levels had decreased to approximately 1/5 the value given for the yearly




Location Sketch Map
ORNL Area Surface Drainage

Figure 3

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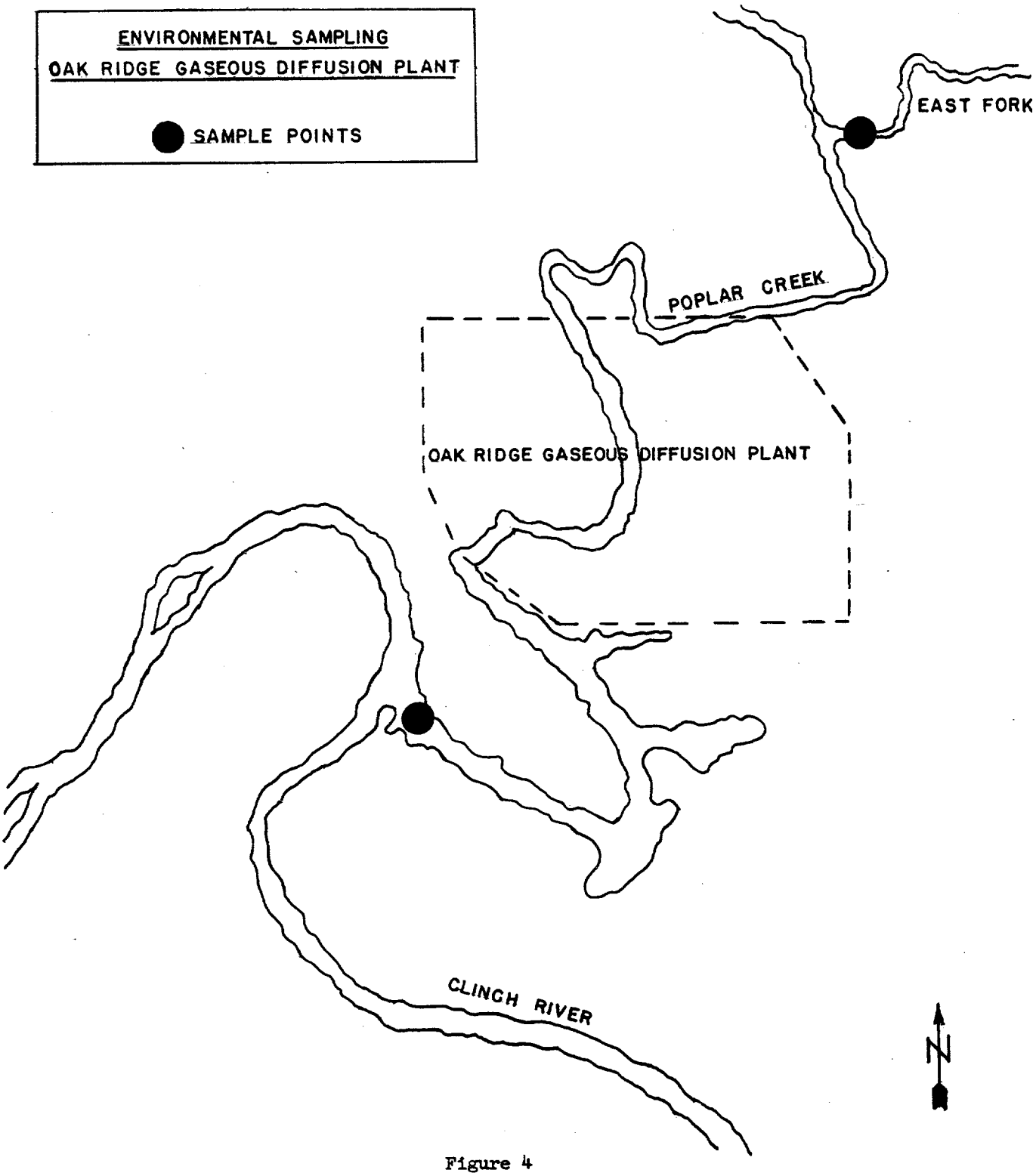


Figure 4

average. Specific analysis for fission products and decay studies indicated that the high levels experienced during the first part of the year were due to the type of fall-out from world-wide weapons testing. The low values for remote stations 23 and 24 resulted from the fact that these stations were in operation only during the latter half of 1959 and do not reflect the higher fall-out levels experienced during the first half of the year.

Fall-out data and rain water data followed the same trend shown by the continuous air monitoring data.

The probable average concentrations of radioactivity in the Clinch River at Mile 20.8, the point of entry of the wastes, and at Mile 4.5, near Kingston, Tennessee, were $3.1 \times 10^{-7}$ μc/cc and $4.9 \times 10^{-8}$ μc/cc respectively. These values are 25.4% and 22.3% of the weighted average maximum permissible concentration for populations in the neighborhood of a controlled area as recommended by the NCRP. The average concentration of transuranic alpha emitters in the Clinch River at Mile 20.8 was $3 \times 10^{-10}$ μc/cc, which is 0.03% of the weighted average $(MPC)_w$ value. The average activity in Poplar Creek below the ORGDP for the entire year was only 0.03% of the maximum permissible concentration for natural uranium.

The concentration of radioactivity in the sediment of the Clinch River drops off materially after the first 20 miles downstream from the entry of White Oak Creek and approaches background levels 200 miles downstream. The average radiation level for the cross section where the highest levels were encountered was approximately 19 times the measured background levels or 0.12 mr/hr. This point is located 4.5 miles below the outfall of White Oak Creek. At 100 miles downstream the average level was approximately twice background.

External gamma radiation levels in the Oak Ridge area averaged 0.024 mr/hr. This level does not differ significantly from the average of the levels measured throughout the United States by the U. S. Public Health Service Radiation Surveillance Network.

TABLE I

CONTINUOUS AIR MONITORING FILTER DATA

Units of $10^{-13}$ µc/cc

1959

| Station Number | Location | Number of Samples Taken | Maximum | Minimum | Average | % of $(MPC)_a$ * |
|---|---|---|---|---|---|---|
| | | Perimeter Stations | | | | |
| HP-11 | Kerr Hollow Gate | 52 | 47.52 | 0.49 | 15.77 | 1.6 |
| HP-12 | Midway Gate | 49 | 81.31 | 0.08 | 16.29 | 1.6 |
| HP-13 | Gallaher Gate | 52 | 58.52 | 0.54 | 16.63 | 1.7 |
| HP-14 | White Wing Gate | 52 | 42.48 | 0.49 | 11.30 | 1.1 |
| HP-15 | Blair Gate | 52 | 61.06 | 0.45 | 19.97 | 2.0 |
| HP-16 | Turnpike Gate | 52 | 51.61 | 0.28 | 13.48 | 1.4 |
| HP-17 | Hickory Creek Bend | 52 | 60.27 | 0.17 | 16.86 | 1.7 |
| Average | | | | | 15.76 | 1.6 |
| | | Remote Stations | | | | |
| HP-19 | Norris Dam | 52 | 86.20 | 0.57 | 23.23 | 2.3 |
| HP-20 | Loudoun Dam | 52 | 90.49 | 0.65 | 22.11 | 2.2 |
| HP-21 | Douglas Dam | 37 | 58.17 | 0.68 | 10.91 | 1.1 |
| HP-22 | Cherokee Dam | 39 | 100.52 | 0.52 | 16.01 | 1.6 |
| HP-23** | Watts Bar Dam | 29 | 35.14 | 0.49 | 5.13 | 0.5 |
| HP-24** | Great Falls Dam | 26 | 10.58 | 0.24 | 2.53 | 0.3 |
| HP-25 | Dale Hollow Dam | 46 | 78.91 | 0.76 | 18.04 | 1.8 |
| HP-26 | Berea, Kentucky | 52 | 54.27 | 0.14 | 13.77 | 1.4 |
| Average | | | | | 13.97 | 1.4 |

* $(MPC)_a$ is taken to be $10^{-10}$ µc/cc as recommended in NBS Handbook 69, Table 4, p. 94.
** Stations in operation only during latter half of 1959.

TABLE II

CONTINUOUS AIR MONITORING FILTER DATA

Particles/1000 cu. ft. of Air Sampled

1959

| Station Number | Location | Number of Samples Taken | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| | | Perimeter Stations | | | |
| HP-11 | Kerr Hollow Gate | 52 | 6.27 | 0.00 | 1.20 |
| HP-12 | Midway Gate | 49 | 6.81 | 0.00 | 1.29 |
| HP-13 | Gallaher Gate | 52 | 5.08 | 0.00 | 0.95 |
| HP-14 | White Wing Gate | 52 | 5.91 | 0.00 | 0.82 |
| HP-15 | Blair Gate | 52 | 10.29 | 0.00 | 1.52 |
| HP-16 | Turnpike Gate | 52 | 5.39 | 0.00 | 0.86 |
| HP-17 | Hickory Creek Bend | 52 | 7.22 | 0.00 | 1.02 |
| Average | | | | | 1.09 |
| | | Remote Stations | | | |
| HP-19 | Norris Dam | 52 | 7.98 | 0.00 | 1.64 |
| HP-20 | Loudoun Dam | 52 | 6.61 | 0.00 | 1.43 |
| HP-21 | Douglas Dam | 37 | 2.83 | 0.00 | 0.28 |
| HP-22 | Cherokee Dam | 39 | 7.26 | 0.00 | 0.54 |
| HP-23* | Watts Bar Dam | 29 | 0.40 | 0.00 | 0.05 |
| HP-24* | Great Falls Dam | 26 | 0.14 | 0.00 | 0.02 |
| HP-25 | Dale Hollow Dam | 46 | 7.96 | 0.00 | 1.01 |
| HP-26 | Berea, Kentucky | 52 | 5.83 | 0.00 | 1.10 |
| Average | | | | | 0.76 |

* Stations in operation only during latter half of 1959.

TABLE III

GUMMED PAPER FALL-OUT DATA

Units of $10^{-4}$ μc/sq. ft.

1959

| Station Number | Location | Number of Samples Taken | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| | | Perimeter Stations | | | |
| HP-11 | Kerr Hollow Gate | 52 | 17.59 | 0.14 | 5.01 |
| HP-12 | Midway Gate | 52 | 18.64 | 0.23 | 5.01 |
| HP-13 | Gallaher Gate | 52 | 17.15 | 0.18 | 4.63 |
| HP-14 | White Wing Gate | 52 | 16.87 | 0.18 | 4.86 |
| HP-15 | Blair Gate | 52 | 23.55 | 0.15 | 5.37 |
| HP-16 | Turnpike Gate | 52 | 28.88 | 0.15 | 5.03 |
| HP-17 | Hickory Creek Bend | 52 | 15.17 | 0.14 | 4.41 |
| Average | | | | | 4.90 |
| | | Remote Stations | | | |
| HP-19 | Norris Dam | 52 | 23.53 | 0.12 | 4.36 |
| HP-20 | Loudoun Dam | 51 | 14.97 | 0.05 | 4.17 |
| HP-21 | Douglas Dam | 37 | 15.20 | 0.04 | 1.99 |
| HP-22 | Cherokee Dam | 39 | 13.45 | 0.07 | 2.51 |
| HP-23* | Watts Bar Dam | 28 | 4.55 | 0.10 | 0.71 |
| HP-24* | Great Falls Dam | 26 | 2.75 | 0.12 | 0.63 |
| HP-25 | Dale Hollow Dam | 46 | 20.75 | 0.14 | 4.26 |
| HP-26 | Berea, Kentucky | 52 | 22.02 | 0.05 | 4.88 |
| Average | | | | | 2.94 |

* Stations in operation only during latter half of 1959.

TABLE IV

GUMMED PAPER FALL-OUT DATA

Particles/sq. ft.

1959

| Station Number | Location | Number of Samples Taken | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| | | Perimeter Stations | | | |
| HP-11 | Kerr Hollow Gate | 52 | 77.00 | 0.00 | 11.96 |
| HP-12 | Midway Gate | 52 | 97.00 | 0.00 | 12.85 |
| HP-13 | Gallaher Gate | 52 | 84.00 | 0.00 | 10.50 |
| HP-14 | White Wing Gate | 52 | 82.00 | 0.00 | 10.13 |
| HP-15 | Blair Gate | 52 | 97.00 | 0.00 | 12.15 |
| HP-16 | Turnpike Gate | 52 | 76.00 | 0.00 | 9.50 |
| HP-17 | Hickory Creek Bend | 52 | 59.00 | 0.00 | 9.50 |
| Average | | | | | 10.94 |
| | | Remote Stations | | | |
| HP-19 | Norris Dam | 52 | 47.00 | 0.00 | 6.23 |
| HP-20 | Loudoun Dam | 31 | 46.00 | 0.00 | 5.27 |
| HP-21 | Douglas Dam | 37 | 14.00 | 0.00 | 0.51 |
| HP-22 | Cherokee Dam | 39 | 11.00 | 0.00 | 0.90 |
| HP-23* | Watts Bar Dam | 28 | 3.00 | 0.00 | 0.41 |
| HP-24* | Great Falls Dam | 26 | 3.00 | 0.00 | 0.19 |
| HP-25 | Dale Hollow Dam | 46 | 59.00 | 0.00 | 4.54 |
| HP-26 | Berea, Kentucky | 52 | 63.00 | 0.00 | 7.19 |
| Average | | | | | 3.16 |

* Stations in operation only during latter half of 1959.

TABLE V

RADIOACTIVITY IN RAIN WATER

Units of $10^{-7}$ μc/cc

1959

| Station Number | Location | Number of Samples Taken | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| | | Perimeter Stations | | | |
| HP-11 | Kerr Hollow Gate | 44 | 42.59 | 0.11 | 7.22 |
| HP-12 | Midway Gate | 44 | 40.38 | 0.14 | 6.30 |
| HP-13 | Gallaher Gate | 44 | 38.72 | 0.12 | 6.10 |
| HP-14 | White Wing Gate | 43 | 43.47 | 0.09 | 6.53 |
| HP-15 | Blair Gate | 39 | 39.36 | 0.19 | 5.78 |
| HP-16 | Turnpike Gate | 44 | 54.84 | 0.15 | 8.82 |
| HP-17 | Hickory Creek Bend | 43 | 54.18 | 0.10 | 8.14 |
| Average | | | | | 6.98 |
| | | Remote Stations | | | |
| HP-19 | Norris Dam | 45 | 89.98 | 0.13 | 11.26 |
| HP-20 | Loudoun Dam | 49 | 138.47 | 0.04 | 14.65 |
| HP-21 | Douglas Dam | 31 | 36.68 | 0.06 | 3.86 |
| HP-22 | Cherokee Dam | 33 | 32.20 | 0.13 | 4.41 |
| HP-23* | Watts Bar Dam | 23 | 6.89 | 0.20 | 1.32 |
| HP-24* | Great Falls Dam | 21 | 8.22 | 0.07 | 1.41 |
| HP-25 | Dale Hollow Dam | 41 | 41.00 | 0.21 | 8.02 |
| HP-26 | Berea, Kentucky | 44 | 47.28 | 0.14 | 10.14 |
| Average | | | | | 6.88 |

* Stations in operation only during latter half of 1959.

TABLE VI

PROBABLE AVERAGE CONCENTRATION OF RADIOACTIVITY
IN THE CLINCH RIVER AT MILE 20.8

Units of $10^{-7}$ µc/cc

1959

| Number of Samples Taken | Maximum | Minimum | Average | % of $(MPC)_w$ |
|---|---|---|---|---|
| 365 | 36.4 | 0.37 | 3.1 | 25.4 |

TABLE VII

AVERAGE CONCENTRATION OF MAJOR RADIOACTIVE CONSITUENTS
IN THE CLINCH RIVER

1959

| Location | Sampling Period | Units of $10^{-8}$ µc/cc $Sr^{90}$ | $Ce^{144}$ | $Cs^{137}$ | $Ru^{103-106}$ | $Co^{60}$ | Probable Avg. Concen. of Radioactivity µc/cc x $10^{-8}$ | $(MPC)_w^a$ $10^{-6}$ µc/cc | % of MPC |
|---|---|---|---|---|---|---|---|---|---|
| Clinch River | | | | | | | | | |
| Mi. 37.5 | 10/1/59 - 1/29/60 | 0.11 | 0.10 | * | * | * | 0.45 | 0.21 | 2.14 |
| Mi. 20.8[b] | 12/28/58 - 12/27/59 | 2.00 | 1.5 | 1.9 | 7.4 | 1.8 | 31.0 | 1.22 | 25.4 |
| Mi. 4.5 | 10/23/58 - 11/3/59 | 1.86 | 0.54 | 0.53 | 1.14 | 0.23 | 4.9 | 0.22 | 22.3 |

[a] Weighted average $(MPC)_w$ calculated for the mixture using $(MPC)_w$ values for specific radionuclides recommended in the NBS Handbook 69.

[b] Values given for this location are calculated values based on the levels of waste released and the dilution afforded by the river.

* None detected.

TABLE VIII

EXTERNAL GAMMA RADIATION LEVELS

mr/hr

1959

| Station Number | Location | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Solway Gate | .022 | .026 | .028 | .027 | .033 | .028 | .025 | .019 | .020 | .015 | .016 | none taken | .024 |
| 2 | Y-12 East Portal | .016 | .021 | .024 | .020 | .026 | .017 | .022 | .015 | .019 | .014 | .013 | " | .019 |
| 3 | Newcomb Road Oak Ridge | .018 | .020 | .025 | .023 | .026 | .024 | .023 | .015 | .022 | .016 | - | " | .021 |
| 4 | Gallaher Gate | .025 | .025 | .030 | .030 | .032 | .034 | .025 | .021 | .025 | .022 | - | " | .027 |
| 5 | White Wing Gate | .031 | .028 | .022 | .032 | .029 | .035 | .036 | .018 | .025 | .019 | .019 | " | .027 |
| Average | | | | | | | | | | | | | | .024 |

TABLE IX

CONCENTRATION OF RADIOACTIVITY IN POPLAR CREEK

1959

| Location of Point | Type of Analysis Made | No. of Samples | Units of $10^{-8}$ μc/cc | | | | |
|---|---|---|---|---|---|---|---|
| | | | Maximum | Minimum | Average | $(MPC)_w$ | Percent $(MPC)_w$ |
| Upstream (East Fork) | Uranium Concentration | 52 | 8.7 | 3.7 | 6.2 | 2000 | 0.31 |
| Downstream (Outfall) | " | 52 | 1.0 | 0.5 | 0.6 | 2000 | 0.03 |
| Upstream (East Fork) | Total Beta Activity | 52 | 22.0 | 14.0 | 18.0 | 2000 | 0.9 |
| Downstream (Outfall) | " | 52 | 32.0 | 11.0 | 22.0 | 2000 | 1.1 |

Normal Sampling Frequency: Continuous sampling; composited over one week.

TABLE X

RADIOACTIVITY IN THE BOTTOM SEDIMENT OF POPLAR CREEK

Units of $10^{-8}$ μc/g

1959

| Location of Point | Type of Analysis Made | No. of Samples | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| Upstream (East Fork) | Uranium Concentration | 4 | 6900 | 400 | 3200 |
| Downstream (Outfall) | " | 4 | 4500 | 1300 | 2500 |
| Upstream (East Fork) | Total Beta Activity | 4 | 28,600 | 7200 | 18,000 |
| Downstream (Outfall) | " | 4 | 21,200 | 12,900 | 18,500 |

Normal Sampling Frequency: Grab sample, once each quarter at each location.